

# Culture and the Independent Self: Obstacles to environmental sustainability?



Hikaru Komatsu<sup>a,1,\*</sup>, Jeremy Rappleye<sup>a,1</sup>, Iveta Silova<sup>b,1</sup>

<sup>a</sup> Graduate School of Education, Kyoto University, Japan

<sup>b</sup> Center for Advanced Studies in Global Education, Arizona State University, United States

## ARTICLE INFO

### Article history:

Received 17 June 2018

Received in revised form 20 February 2019

Accepted 22 February 2019

Available online 28 February 2019

### Keywords:

Anthropogenic perception

Climate change

Culture

Ecological Footprint

Education

Independent self

## ABSTRACT

The centrality of culture for achieving environmental sustainability has long been underscored by philosophers, psychologists, and social scientists concerned about the environment. However, to date few studies have detected an empirical relationship between cultural dimensions and actual environmental impacts on Earth (e.g., the Ecological Footprint, EF). This study examined the hypothesis that an individualistic society, herein defined as one whose members predominantly believe in forms of independent self-construal, would exhibit a higher environmental impact compared to a less individualistic society, herein defined as one where the prevailing belief is in interdependent selfhood. This study tested three sub-hypotheses. First, due to the dominance of the independent self, people in an individualistic society tend to be less inclined to believe that human activities cause environmental problems (i.e., lower levels of anthropogenic perception). Second, these low levels of anthropogenic perception prevent members of individualistic societies from consciously organizing pro-environmental behavior, resulting in a higher environmental impact. Third, even among countries with similar levels of anthropogenic perception, those in individualistic societies would exhibit higher environmental impacts due to less self-control when facing trade-offs between individual and social benefits. To examine these hypotheses, the study used three indices comprising country-level data including Hofstede's 'individualism-collectivism' scale, EF, and anthropogenic perception of climate change. Results confirm higher EF for more individualistic countries, supporting the main hypothesis and confirming positive results for all subhypotheses. The findings suggest that although the independent self has traditionally been a major cornerstone of western civilization and been valorized in other places worldwide during the modern era, rewriting this culturally-derived concept of self might now be necessary to move towards greater environmental sustainability

© 2019 Elsevier Ltd. All rights reserved.

## 1. Introduction

Environmental problems abound: deforestation, air pollution, water pollution, fossil fuel scarcity, climate change, and ocean acidification. Human society utilizes more resources than Earth can regenerate and emits more waste than Earth can absorb, a compelling hypothesis first put forth in the seminal work *The Limits to Growth* (Meadows et al., 1972). Published almost 50 years ago, the work provocatively suggested that human society would face environmental catastrophe (e.g., drastic decline in population and human welfare) if it continued along its existing trajectory.

The past several decades have witnessed various attempts to change course. Examples include: successful dissemination of scientific research results related to environmental problems (Brechin and Bhandari, 2011), improving energy and resource efficiency relative to economic output (Jackson, 2009), and various international agreements aimed at reducing emissions including the 1997 Kyoto Protocol and 2015 Paris Agreement (Falkner, 2016). Despite these efforts, human society has not been successful in significantly lessening the potential for environmental catastrophe (Randers, 2012). Indeed, recent studies reveal that human society is still tracking the catastrophe trajectory first foretold in *The Limits to Growth* (Turner, 2008, 2012).

In light of this, an increasing number of scholars surmise that there is an underlying structure (i.e., culture) which has prevented society from changing its trajectory (e.g., Meadows et al., 2004; Klein, 2014). For example, authors of *The Limits to Growth: The 30-year Update* recently lamented: "The culture tends to deny the

\* Corresponding author at: Kyoto University, Graduate School of Education Ushinomiya-cho, Sakyo-Ku, Kyoto, 606-8501, Japan.

E-mail address: [kmthkra@gmail.com](mailto:kmthkra@gmail.com) (H. Komatsu).

<sup>1</sup> All authors contributed equally to this piece.

possibility of limits by placing a profound faith in the powers of technology, the workings of a free market, and the growth of the economy as the solution to all problems" (Meadows et al., 2004, p. 203, italics added), then continued: "the world faces not a preordained future, but a choice. The choice is between different *mental models*, which lead logically to different scenarios" (p. 283, italic added). Although that work does define 'mental models', we surmise that the general idea is frequently encapsulated by the term 'culture', which we employ here. Yet like 'mental models', culture must not be understood as merely an inert or stable set of beliefs or values 'stored' inside people but rather as patterns of sense making materialized in actual practices, everyday lives, and societal institutions (see Markus and Kitayama, 2010).

In terms of culture, philosophers, psychologists, and social scientists concerned about the environment have long underscored its importance for sustainability (e.g., White, 1967; Schumacher, 1973; Bowers, 1995, 2002; Orr, 1998; Schultz, 2001; Wang, 2016). These concerns have recently begun to come to the fore in fields of research open to interdisciplinarity, particularly those willing to combine science with social science to explore relationships between people's beliefs and major environmental problems (Weber, 2010; Adger et al., 2013; Lee et al., 2015). Nonetheless, such emerging discussions surrounding the intersection of culture and environmental problems have often stalled, remained confined to narrow academic circles, and largely failed to capture the attention of the wider public.

We surmise that one major reason for this neglect of culture is that very few studies have detected an empirical relationship between cultural dimensions and actual environmental impacts on Earth (e.g., the Ecological Footprint of Consumption). Without the empirical case, scientists that frequently work from the assumption of cultural objectivity remain skeptical, while social scientists have a difficult time making the bridge to 'hard' environmental impacts. We note here that the field of environmental psychology focuses primarily on the effects of cultural dimensions on pro-environmental attitudes and behavior, not on actual environmental impacts on Earth (e.g., Schultz, 2001; Frantz et al., 2005; Arnocky et al., 2007). The absence of findings that link beliefs and impacts prevents all – scientists, social scientists, and the wider public – from affirming the importance of culture in achieving environmental sustainability.

Hoping to fill this gap and forge a preliminary bridge of sorts, this study reports a clear relationship between a particular dimension of culture and Ecological Footprint of Consumption (EF) using country-level quantitative data. Specifically, this study reports higher EF for more individualistic countries. This relationship suggests that the specific form of self-construal (i.e., independent self) observed widely in individualistic societies is one major obstacle to environmental sustainability. Considering that self (i.e., the 'me' at the center of experience) is aligned with its social environment and therefore contributes to keeping the society moving along the current trajectory, rewriting this notion of self by introducing practices from less individualistic cultures could potentially contribute to moving human society off the existing catastrophe trajectory.

## 2. Basic concepts and hypotheses

### 2.1. Basic concepts

In order to frame the subsequent hypotheses, a basic definition of the key concepts of culture and self is necessary. As discussed above, culture should not be thought of as a stable set of beliefs or values stored inside people but rather as something materialized in patterns of practices and institutions (Kasulis, 2002; Adams and Markus, 2004). An individual born in a society develops one's self

through practices in a given society. The self then reproduces and reshapes practices and institutions within that society. That is, culture and self interact with each other in a system of 'mutual constitution' (Markus and Kitayama, 2010).

Forms of self-construal are known to often differ from one culture and/or society to another. Independent self-construal is dominant in individualistic societies (e.g., the United States, the United Kingdom, and Australia), whereas interdependent self-construal is dominant in collectivistic societies (e.g., most countries outside Europe and North America). Although much diversity and differences in degree exist in forms of self-construal, the broad distinction between independent self and interdependent self has been confirmed as one possible and 'powerful heuristic' (Markus and Kitayama, 2010) to conceptualize these differences. Indeed, this divergence can be linked to numerous measurable effects from psychological functioning to social preferences, as repeatedly demonstrated in successive empirical studies across psychology and related fields (see Heine and Ruby, 2010). We follow others in calling these heuristic tools 'ideal types' herein to underscore that these are tools for analysis, and that a given individual is actually neither completely independent nor interdependent (Triandis, 1995). These heuristics were proposed by cultural psychologists (Markus and Kitayama, 1991, 2010) as analytical tools, and any society will be comprised of both types even as the relative proportion would vary according to time, place, and circumstances. Diversity certainly exists, but so do dominant patterns.

But what do these terms denote and what are the behavioral effects? An individual whose dominant form of self-construal is independent tends to organize his or her behavior by referring primarily to one's own thoughts and feelings. In contrast, one whose dominant form of self-construal is interdependent tends to organize one's behavior by referring primarily to thoughts, feelings, and actions of others (Markus and Kitayama, 1991, 2010). These differences stem from fundamental differences in perceptions of the world, with many philosophers preferring the term ontology. For an independent self, the basic unit of the world is most frequently assumed to be an atomized element, understood as an ontologically distinct entity (Nisbett, 2003). Consequently, an independent self assumes, from the outset, that one's self exists independently from other elements and that the self then creates relationships with other elements in accordance with one's own necessity and desires. That is, relationships with others are assumed to be secondary (Kasulis, 2002). For an interdependent self, on the other hand, relationships rather than entities are the constituent elements of the world. That is, the assumption is that entities, including self, co-arise out of primary relationships and therefore entities are ontologically inseparable from webs of relations.

Independent self-construal – or what we call simply the independent self – is dominant (but again not absolute) in individualistic societies, because individuals shaped in those societies learn the concept of independent self through repeated daily practices. For example, in preschools in the United States, individual choice is strongly emphasized. A well-known, widely cited longitudinal study found that preschool teachers in the United States tend to consistently have students select their activities for themselves as soon as the students arrive at school (Tobin et al., 2009, p. 193). The assumption is that "young children . . . have an inalienable right to the pursuit of happiness and fun, and activities that are individually chosen are assumed to be inherently more pleasurable than those that are collectively chosen or assigned" (Tobin et al., 2009, p. 195). Chinese preschools, by contrast, include many group activities, including morning exercise. Preschool teachers in China do not see group activities as those ignoring individual desires. Instead, Chinese teachers see

group activities as integral for students to feel "the pleasure of merging one's desires with the desires of the group and the satisfaction of being a member" (Tobin et al., 2009, p. 53). Through such activities, educational and otherwise, a given society tends to reproduce persons having a particular and dominant mode of self-construal, ones that fit into and support activities, institutions, and even theories governing given societies. This mutually constitutive relationship between constructs of culture (e.g., practices and institutions) and self-construal explains why independent selves remain more prevalent in individualistic societies and vice-versa, even after the historical contingencies creating such differences are no longer immediately felt.

## 2.2. Hypotheses

We hypothesize that an individualistic society primarily comprised of independent selves tends to have a higher per capita environmental impact than a collectivistic society comprised of interdependent selves. We further hypothesize two different pathways through which the extent of individualism relates to environmental impact.

The first pathway is through anthropogenic perception. We assume that people in an individualistic society tend not to believe environmental problems are caused by human activities (i.e., they have lower levels of anthropogenic perception) compared to those in a collectivistic society. This is due, at least in part, to differences in the nature of dominant self-construal. Lower levels of anthropogenic perception would, in turn, prevent individuals in an individualistic society from consciously engaging in pro-environmental behavior, resulting in a higher environmental impact.

The second pathway is through self control. Pro-environmental behavior requires a higher level of self control because pro-environmental behavior frequently conflicts with personal benefit. We surmise that those possessing independent selves would be less accustomed to controlling their own desire for the sake of the collective social benefit. This would result in the lower likelihood of pro-environmental behavior and a consequently higher environmental impact for more individualistic societies. This would be the case even when there is no difference in overall levels of anthropogenic perception across given societies.

These hypotheses were largely derived from a review of existing studies in cultural, social, and environmental psychology. To the best of our knowledge, there has been no study reporting a relationship between self-construal and anthropogenic perception. However, previous studies in cultural psychology (Morris and Peng, 1994; Nisbett and Masuda, 2003) have suggested that an independent self tends to be less concerned with relationships among entities. This is largely attributable to the specific worldview of independent self (i.e., the world is comprised of entities). Indeed, Morris and Peng (1994) reported that, for example, Americans (who construe themselves as primarily independent) frequently attribute a particular murder to the attributes of the culprit (e.g., personal qualities, political beliefs, and/or psychological or mental health issues), while Chinese (who construe themselves as primarily interdependent) attribute the exact same murder to social interactions the killer may have had (e.g., troubled relations with his boss, colleagues, or family, and/or wider social conditions). If we extend this to assume that an independent self is less concerned with not only between-human relationships but human-nature relationships, it is plausible that people in an individualistic society are more likely to believe that an environmental problem is caused by natural variability (i.e., properties inherent in the different entities), not by human-nature relations.

Indeed, we located several studies in environmental psychology supporting our assumption that an independent self is less concerned with both between-human and human-nature relationships. Both Arnocky et al. (2007) and Davis and Stroink (2016) found that the independent self-construal positively predicted egoistic environmental values (i.e., degrees of concern about environmental degradation because of the negative impact it will have on oneself) rather than biospheric concern (i.e., caring about environmental degradation because humans are a part of nature). Schultz et al. (2005) further found that people in the United States espouse stronger egoistic environmental values in comparison to people residing in non-Western cultures. Milfont et al. (2011) found that priming of independence within a Western context resulted in a decreased sense of connectedness with nature and a reduction in the perceived seriousness of environmental issues. Furthermore, Hwang and Lee (2018) recently reported that, although the independent self-construal positively predicted the New Ecological Paradigm (i.e., fundamental belief about the interconnection between people and the environment, see Dunlap et al., 2000), the predictive relation between the independent self and the New Ecological Paradigm was much weaker than that between the interdependent self and the New Ecological Paradigm. These recent studies in environmental psychology collectively suggest that an independent self embodies less human-nature overlap (i.e., tends to view oneself as separate from nature) and are consequently less concerned with human-nature relationships, as we hypothesized above.

Concerning the relationship between anthropogenic perception and environmental impacts, previous studies in environmental psychology (Lee and Holden, 1999; Lubell, 2002) reported that people who understand their own contributions to the environmental problems tended to engage in pro-environmental behavior. This suggests the validity of assuming a higher environmental impact for societies with a higher level of anthropogenic perception. It is true that people sometimes engage in pro-environmental behavior without understanding their contributions to environmental problems (e.g., commuting with a bike to improve one's health), as Gifford (2011, 2014) has pointed out. However, it is also true that anthropogenic perception is a prerequisite for people to consciously engage in pro-environmental behavior.

Concerning the relationship between self-construal and self control, one previous study in environmental psychology (Chuang et al., 2016) reported that the independent self is less effective in controlling one's own desire for the sake of collective social benefit and consequently less willing to engage in pro-environmental behavior (e.g., paying an additional cost for environmentally-friendly products). Other psychological studies also suggested that the independent self showed lower self control than the interdependent self (Seeley and Gardner, 2003) and further that the trait of self control correlates with pro-social behavior (Martinsson et al., 2012), although these studies were not conducted in the context of environmental problems. Supporting Chuang et al.'s (2016) findings, another study in environmental psychology (Arnocky et al., 2007) reported that an independent self cooperated less effectively with others than interdependent selves under hypothetical conditions of resource constraints. This finding also supports the idea that independent selves control their behavior in response to environmental problems less effectively than interdependent selves.

Most of the studies cited above were conducted at a small scale within one particular society. We extrapolate the findings of these studies to an international scale and advance the following hypotheses, each empirically examined in detail in the analysis that follows:

**Main Hypothesis.** Individualistic countries have a higher environmental impact on Earth than collectivistic countries.

**Subhypothesis #1.** Individualistic countries have a lower level of anthropogenic perception than collectivistic countries.

**Subhypothesis #2.** Countries having a lower level of anthropogenic perception have a higher per capita environmental impact.

**Subhypothesis #3.** Even among countries having a similar level of anthropogenic perception, individualistic countries have a higher environmental impact than collectivistic countries.

### 3. Data used

#### 3.1. Overview

To examine these hypotheses, we used the following three datasets, all comprised of country-level data (Supplementary Dataset 1). To understand degrees of individualism, we used Hofstede et al.'s (2010) cultural dimension dataset, which includes individualism scores for various countries wherein a higher score (0–100) indicates a higher level of individualism. To capture people's attitude towards environmental problems, we used data for perception of climate change derived from the Gallup Poll 2007–2008 (Pelham, 2009; Pugliese and Ray, 2009). This dataset provides the percentage of people in a country who believe rising temperatures are a result of human activities (i.e., anthropogenic perception). To represent actual environmental impacts on Earth, we used data for Ecological Footprint of Consumption (EF) for various countries (Global Footprint Network, 2017). EF is an index representing the land areas a country requires to produce the natural resources it consumes (including plant-based food and fiber products, livestock and fish products, timber and other forest products, and space for urban infrastructure) and to absorb its waste, especially carbon emissions. The unit of EF is "the number of Earths demanded" assuming that the world population consumes in the same way as the average person for a given country.

To supplement our analysis, we use data for life expectancy (UNDP, 2016) to represent the extent of development of each country. The extent of development is quite often assessed using an economic index (e.g., Gross Domestic Product per capita) or with aggregated indices that account for not only wealth but also education and health (e.g., Human Development Index). We, however, do not use these indices. These indices are all based on high modern assumptions that industrial-led economic growth and modern schooling are unequivocally good. Since this study attempts, in part, to relativize the cultural assumptions underpinning modernity, we try to avoid these first assumptions as the starting point for research. Life expectancy is based on the more basic assumption that a healthy and long life is good, a valuation not specific to any given culture, society, or historical epoch.

One possible concern about using life expectancy to represent the extent of development is that life expectancy is affected by genetic and other non-social factors as well as by the extent of development (Passarino et al., 2016). Previous studies reported considerable differences in life expectancy between ethnic groups in a given society (Crimmins and Saito, 2001; Olshansky et al., 2012). However, these between-group differences seemed to be largely attributable to social factors. Indeed, between-group differences in life expectancy among people with a high level of education are much smaller than those among people with a low level of education (Crimmins and Saito, 2001; Olshansky et al., 2012). This suggests that only a limited portion of the between-country differences in life

expectancy are attributable to non-social factors, adequately justifying the use of life expectancy to represent the extent of development herein.

#### 3.2. Individualism score

Individualism scores were derived from a recently updated version of the Hofstede's cultural dimensions dataset (Hofstede et al., 2010). This dataset assesses cultural characteristics for various countries and has been widely used. Among several cultural indices therein, we used the data for the individualism-collectivism dimension. The score of this dimension for a given country ranges between 0 and 100 with higher values indicating greater individualism.

This score was derived based on questionnaire responses. Respondents were requested to rate their location for sets of statements, including "the conventions and rules of the group I belong to influence my behavior" (1) and "I have full personal freedom" (5). The rating scores for various sets of statements were summed to obtain the individualism-collectivism dimension score.

In this study, we used the independence-interdependence dichotomy at an individual scale, which corresponds to the mean differences in the individualism-collectivism scale differences at a societal scale. Several scholars have cautioned that the use of a binary independent-interdependent conceptualization could nullify other forms of self-construal (e.g., Voronov and Singer, 2002; Arnocky et al., 2007; Stroink and DeCicco, 2011). However, it is also true that most still confirmed the analytical utility of the independent-interdependent conceptualization (e.g., Stroink and DeCicco, 2011). We also note that recent work in cultural psychology has evolved towards new methodologies of measurement and experimental methods that have some advantages over Hofstede's self-reported scale (see Markus and Kitayama, 2010, p. 426), but even this recent work largely confirms the relevance of the Hofstede scales.

#### 3.3. Anthropogenic perception

To assess how much a society assumes that environmental problems are primarily caused by human activities, we used data for perception of climate change derived from Gallup Poll 2007–2008 (Pelham, 2009; Pugliese and Ray, 2009). That is, we assumed that people's anthropogenic perception of various environmental problems corresponds to that of climate change. Our reasons for this approach are three-fold. First, country-scale data for public perception of climate change were readily available. This contrasted with the lack of data for public perception of most other environmental problems. Second, data for climate change would allow us to detect between-country differences in perception. Since the relationship between human activities and climate change is indirect, we would expect a large variation in public perception of global warming among countries. This would contrast with the case for environmental problems which have a more direct, local link with human activities (e.g., water pollution). In such cases, we surmise almost all respondents would perceive that the environmental problem is a consequence of human activities, i.e., the variation in anthropogenic perception among countries would be very small. Third, the most plausible cause of climate change (i.e., carbon dioxide, CO<sub>2</sub>) aggregates various human activities which link with other major environmental problems (e.g., deforestation and oil scarcity). For these reasons, we used the data for public perception of global warming as an aggregated measure for public perception of various environmental problems. Representing general environmental problems by focusing on climate change is partially corroborated by previous studies, which show that countries wherein people are

willing to pay to protect the environment generally tended to be willing to pay to address climate change specifically (Pew Research Center, 2010; Brechin and Bhandari, 2011).

Our data here were the percentage of the respondents for a given country who believe rising temperatures are a result of human activities (Pelham, 2009). In the survey conducted in 2007 and 2008, respondents were asked to read the following sentences: "Temperature rise is a part of global warming or climate change. Do you think rising temperatures are . . . a result of human activities?" The respondents were allowed to select one option among the three: a result of human activities, a result of natural cause, or a result of both. We used the percentage of respondents who selected the first response. Note that Gallup Poll is, to our knowledge, the only global survey including a question about anthropogenic perception of climate change among major surveys on people's perception of climate change (World Bank, 2009; Pew Research Center, 2010, 2015).

Beside data for anthropogenic perception, the Gallup Poll includes data for the percentages of people who were aware of climate change and who viewed climate change as a personal threat (Pugliese and Ray, 2009). Concerning the former, respondents were asked "How much do you know about global warming or climate change?" and allowed to select one option among four: (1) have not heard of it, (2) know something about it, (3) know a great deal about it, or (4) don't know/refused. The percentage of those who selected the second or third options was used in the analysis. Concerning the latter, respondents were asked "How serious of a threat is global warming to you and your family?" and allowed to select one option among the four: (1) very/somewhat serious, (2) not very/not serious at all serious, (3) don't know/refused, or (4) not aware. The percentage of those who selected the first option was used in the analysis. Another advantage of the Gallup Poll as compared with other major surveys (World Bank, 2009; Pew Research Center, 2010, 2015) is that it is explicit about for whom climate change is an existential threat (i.e., to the individual, not to the society or nature). The lack of such information among other surveys makes the interpretation of results more difficult given that different rationale behind such concerns is at play (e.g., egoistic, altruistic, and biospheric concerns; for discussion of this issue see Schultz, 2001; Arnocky et al., 2007).

#### 3.4. Ecological Footprint (EF)

Data for country-scale Ecological Footprint of Consumption (EF) in 2013 were derived from the Global Footprint Network (2017). EF is useful in that it considers the trade-off between different forms of consumption (York et al., 2004). Suppose that a given country replaces timber utilized in the country with industrially processed materials. This country would successfully reduce the consumption of timber, but the country will enhance its CO<sub>2</sub> emission from the processed materials. Other indices, such as the consumption of timbers and CO<sub>2</sub> emission, would not consider the inevitable trade-off between timbers and industrially produced materials.

Since the data quality of EF differ among countries, we used data for countries of which quality scores were 5 or 6. The quality score being 6 denotes that "no component of . . . EF is unreliable or unlikely for any year". The quality score being 5 denotes that "no component of . . . EF is unreliable or unlikely for the latest data year".

Besides EF, there exist other major environmental indices including the Environmental Sustainability Index (ESI) and the Environmental Performance Index (EPI) (e.g., Siche et al., 2008). We chose not to use ESI and EPI because these indices do not assess global-scale environmental sustainability (Wilson et al., 2007). Instead, ESI and EPI assess environmental sustainability at a local scale. This can create distortions and omissions. For example, when

a given country imports a large number of timber from foreign countries to preserve its own forests, such countries would be assessed as environmentally successful on the ESI and EPI. In this study, our primary concern is global environmental sustainability and therefore we used EF.

#### 3.5. Additional data

We used data for life expectancy, Gross Domestic Product (GDP) per capita, population density, land area, and oil revenue in 2015 for selected countries. Data for life expectancy were derived from the UNDP's (2016) Human Development Report. All other data were derived from the World Bank (2017).

#### 3.6. Selection of countries

Analyses were made for countries satisfying the following three criteria. First, the country must have had reliable data for life expectancy. Since we used life expectancy to categorize countries having a similar developmental level, countries lacking life expectancy data in the UNDP dataset were excluded from the analysis. We thus excluded Guadeloupe, North Korea, Réunion, Somalia, Taiwan, and Wallis and Futuna Islands.

Second, the country must have had at least two of the following types of data: individualism score, anthropogenic perception, and EF. This criterion was needed because the analysis was based on correlation analysis of the three variables. Based on this criterion, we excluded some countries such as Bhutan and Sudan.

Third, the country must have been neither a very small country nor an oil exporting country. More specifically, the country must have had land area greater than 10,000 km<sup>2</sup> and oil revenue comprising less than 10% of its GDP. Very small countries and oil exporting countries quite often show vastly divergent energy consumption patterns from those for other countries (e.g., Mehrara, 2007; Weber et al., 2008). To account for this, we note that a similar distinction is frequently employed in energy research (e.g., Linderoth, 2002). We thus excluded Angola, Azerbaijan, Democratic Republic of the Congo, Guinea, Iraq, Luxembourg, Saudi Arabia, Singapore, and Trinidad and Tobago.

As a consequence, the sample size for our primary analysis was 105 countries (Supplementary Dataset 1). In the main analysis, focusing on countries having life expectancy no less than 75.5 years, we used 33, 34, and 32 samples for examining the relationships between the independence score and anthropogenic perception, between anthropogenic perception and EF, and between the individualism score and EF, respectively.

#### 3.7. Statistical analyses

To examine relationships among independence scores, anthropogenic perception, and EF, we utilized a simple correlation analysis using the Pearson correlation coefficient (*r*). Since *r* is highly affected by outliers, we calculated 95 percent confidence intervals to examine the stability of the correlation. For this, we obtained random samples from the original data with replacement using a bootstrapping method and calculated *r* values 10,000 times and then identified the range in which 95 percent of the *r* values fell (the confidence interval, CI) (Diadonis and Efron, 1983). Note that we confirmed that iterating more than 10,000 times did not change the calculated CIs considerably.

We did not perform hypothesis testing to examine statistical significance of the relationships. Statistical significance is not always meaningful in a practical context. A very weak relationship can be found to be statistically significant if we have a large number of samples. This problem has long been noted by prominent statisticians (e.g., Berkson, 1938) and has again become

a concern in recent years (Thompson, 2002; Nuzzo, 2014; Komatsu and Rappleye, 2017b). It is recommended that in place of significance reporting, it is better to report effect sizes such as  $r$  and its CI. Readers who remain interested in statistical significance of the relationships examined in this study can, of course, infer the significance on the basis of the reported  $r$  and CI.

Throughout this study, we did not employ multiple linear regression analysis. Although multiple linear regression analysis is widely used, particularly by social scientists, using this method embeds untested assumptions. We surmised that these untested assumptions could be one major reason why previous studies failed to identify a factor strongly relating with EF and other environmental indices (e.g., Park et al., 2007; Peng and Lin, 2009; Onel and Mukherjee, 2014). One problematic assumption of multiple linear regression analyses is that all independent variables affect the dependent variable in a linear way. But it is quite often the case that several independent variables relate with the dependent variable in a non-linear way. Indeed, our analysis revealed that GDP per capita related with EF in a non-linear manner. While it is also true that simple correlation analysis also assumes linearity between the variables considered, we have shown relevant scatter diagrams for readers to examine the validity of the assumptions. Furthermore, we confirmed that our conclusions did not change when using Spearman's rho instead of  $r$ , even though the former does not assume linearity between the variables considered.

Another problematic assumption of multiple linear regression is that different independent variables affect the dependent variable in an additive manner. In fact, different factors quite often affect in a multiplicative manner, as is widely acknowledged across the natural sciences. Owing to these problems, we chose not to utilize multiple linear regression analysis herein.

Although our analysis is based on simple correlation analysis, we tried to exclude the effects of other factors by focusing on data for countries satisfying certain conditions. Still this analysis does not allow us to judge which of two factors affects the target variable (e.g., EF) when the two factors correlate with each other. We addressed this problem in the discussion section. It is true that using multiple non-linear regression analysis might solve some of the problems of multiple linear regression. However, the lack of the information about the shape of the function expressing the relationship of a factor with EF prohibited us from pursuing this approach. The lack of this information is one consequence of previous studies (Park et al., 2007; Peng and Lin, 2009; Onel and Mukherjee, 2014) which arbitrarily employed multiple linear regression analysis, and thus left unexamined the shape of the function expressing the relationship of a given factor with EF.

## 4. Results

### 4.1. Data overview

For countries having a short life expectancy (< 70 years), individualism scores were generally low (< 40, Fig. 1). However, individualism scores varied greatly among countries having a long life expectancy (Fig. 1). The mean  $\pm$  standard deviation (SD) of individualism scores was  $53 \pm 24$  points for countries having a life expectancy no less than 75.5 years, while they were  $27 \pm 14$  points for countries having a life expectancy less than 75.5 years (Table 1). Setting a threshold of 75.5 years further allowed us to include all the original members of Organisation for Economic Co-operation and Development (OECD). Among these OECD members, countries having high individualism scores tended to be distributed in regions having a strong Christian historical inheritance (Fig. 2). Particularly high scores were recorded for Anglo-American countries (i.e., the United States, Australia, and United Kingdom)



**Fig. 1.** Relationship between life expectancy and individualism scores among countries.

where Protestant traditions are among the strongest. In contrast, countries having low individualism scores tended to be distributed in Asia, Latin America, and peripheral areas of Europe (e.g., Turkey).

The following analysis thus focused on the countries having a life expectancy no less than 75.5 years, which also linked to the relatively higher EF for this group (Table 1): EF of these countries was comprised of 61.7% of global EF despite their relatively small population (39.2% of the world population). The observation of a large variation in EF among these same countries despite the small variation in the life expectancy further supported the analytical focus on these countries (Fig. 3). EF ranged between 1.66 (Vietnam) and 8.80 Earths (the United States). The second reason for focusing on the countries having a life expectancy no less than 75.5 years was that the small variation in individualism scores for the countries having a life expectancy less than 75.5 years (Table 1), which would have made it difficult and ineffective to include all countries within an analysis of the relationship of independence scores with anthropogenic perception and EF. A final reason was that the majority of the countries having a life expectancy no less than 75.5 years (30 among the 39 countries) had all data components (e.g., individualism scores, anthropogenic perception, and EF). This was not the case for the countries having a life expectancy less than 75.5 years: only 21 among the 64 countries had all data components.

### 4.2. Examination of hypotheses

#### 4.2.1. Main hypothesis

Countries having higher individualism scores had higher EF ( $r = .733$ , CI = [.519, .867], Fig. 4). That is, people with higher individualism scores had more detrimental impacts on Earth, supporting the Main Hypothesis.

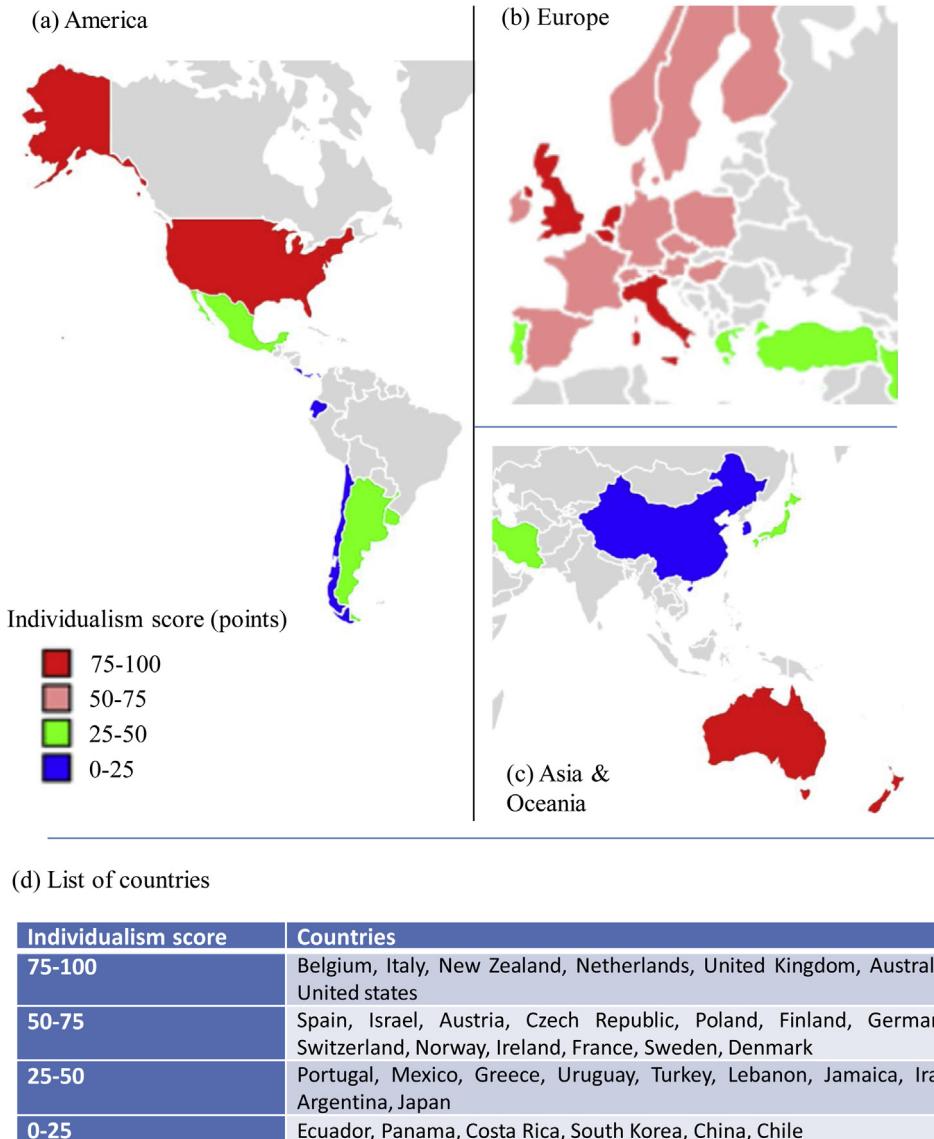
#### 4.2.2. Subhypothesis #1

People in countries having higher individualism scores tended not to believe that rising global temperatures were anthropogenic ( $r = -.758$ , CI = [-.878, -.592], Fig. 5a), thus supporting Subhypothesis #1. This result was particularly impressive in consideration of the fact that people having higher individualism scores tended to be more aware of climate change than people having low

**Table 1**

Mean  $\pm$  SD for individualism scores, percentages of anthropogenic perception, awareness, and risk perception, and Ecological Footprint of Consumption (EF).

| Life expectancy                    | Individualism score (points) | Anthropogenic perception (%) | Awareness (%)          | Risk perception (%)    | EF (Earths)                |
|------------------------------------|------------------------------|------------------------------|------------------------|------------------------|----------------------------|
| Less than 75.5 years ( $n=64$ )    | $27 \pm 14$ ( $n=22$ )       | $53 \pm 16$ ( $n=64$ )       | $53 \pm 20$ ( $n=64$ ) | $41 \pm 16$ ( $n=64$ ) | $1.96 \pm 1.31$ ( $n=64$ ) |
| No less than 75.5 years ( $n=39$ ) | $53 \pm 24$ ( $n=35$ )       | $64 \pm 14$ ( $n=37$ )       | $84 \pm 12$ ( $n=37$ ) | $60 \pm 15$ ( $n=37$ ) | $4.97 \pm 1.70$ ( $n=36$ ) |



**Fig. 2.** Individualism scores for different countries: (a) America, (b) Europe, and (c) Asia and Oceania. Countries having a life expectancy lower than 75.5 years and those lacking data were not colored. (d) List of countries by independence scores.

individualism scores ( $r=.692$ , CI = [.500, .852], Fig. 5b) and felt comparable risk compared to those having low independence scores ( $r=-.104$ , CI = [-.458, .234], Fig. 5c). That is, people with high individualism scores were aware of climate change and perceived it as a threat, but this awareness did not lead them to view climate change as anthropogenic.

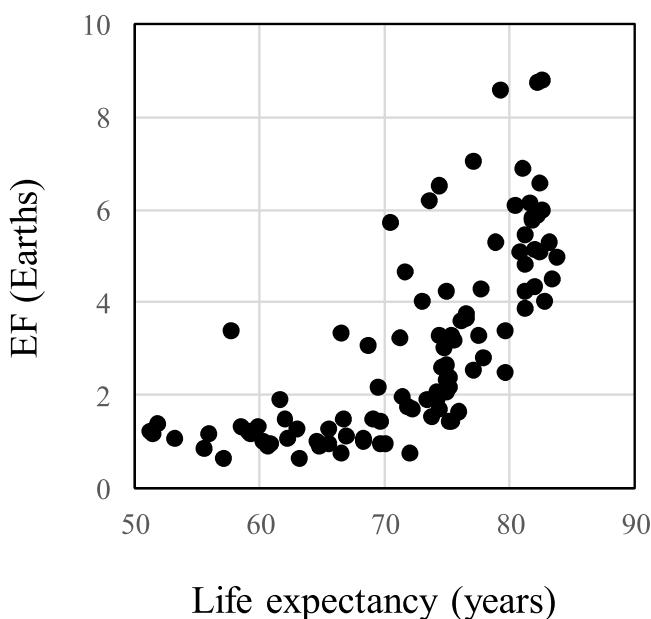
#### 4.2.3. Subhypothesis #2

Countries having a higher percentage of anthropogenic perception had lower EF ( $r = -.440$ , CI = [-.704, -.147], Fig. 6a), thus supporting Subhypothesis #2. That is, people who viewed climate change as anthropogenic had a smaller per capita environmental impact. This contrasts with the relationships of

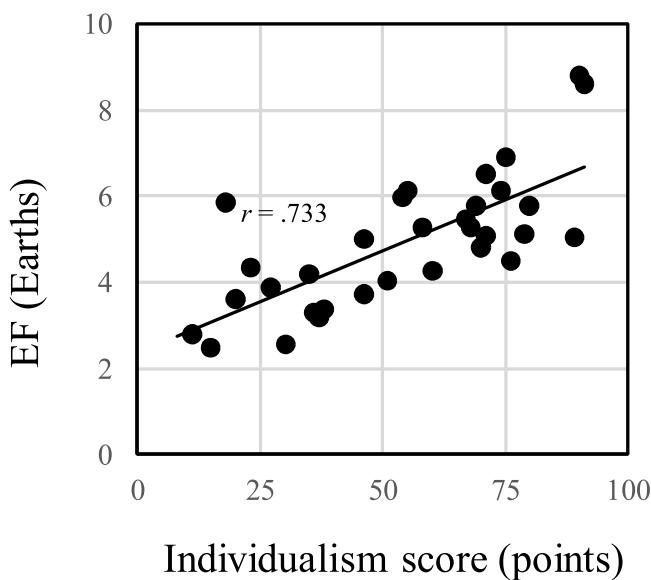
percentages of awareness and risk perception with EF (Fig. 6b and c). People having a higher awareness percentage had higher (not lower) EF ( $r=.747$ , CI = [.652, .832]). People having a higher percentage of risk perception had comparable EF to those having a lower percentage of risk perception ( $r=.0348$ , CI = [-.294, .296]).

#### 4.2.4. Subhypothesis #3

Fig. 7a and b show the relationships between individualism scores and EF for countries having different percentages of anthropogenic perception (i.e., the percentage being 40–60% and 60–80%). We observed positive correlations for the former two groups of countries, i.e.,  $r=.721$ , CI = [.213, .929] for countries having a percentage of 40–60% (Fig. 7a) and  $r=.720$ , CI = [.490,



**Fig. 3.** Relationship between life expectancy and Ecological Footprint of Consumption (EF) among countries.



**Fig. 4.** Relationship between individualism scores and Ecological Footprint of Consumption (EF).

.892] for countries having a percentage of 60–80% (Fig. 7b). These results support Subhypothesis #3. We did not conduct correlation analysis for the countries having a percentage of 80–100%. The small sample size ( $n=5$ ) combined with the small range of individualism scores (15–46 points) for these countries made the analysis irrelevant. Indeed, we calculated the CI for  $r$  using data for these countries as a trial and obtained a CI of [−1.00, 1.00], verifying the sample size was too small.

#### 4.3. Effects of other factors

The relationship between individualism scores and EF (Fig. 4,  $r=.733$ , CI = [.519, .867]) was stronger than that between the population density and EF (Fig. 8a,  $r = -.0625$ , CI = [−.252, .485]), although some previous studies identified population density as a

factor explaining variations in EF (e.g., York et al., 2004; Bradshaw et al., 2010).

GDP per capita showed a correlation with EF ( $r = .720$ , CI = [.576, .855], Fig. 8b). This implies the possibility that the correlation between individualism scores and EF (Fig. 4) might be merely an artefact of the correlation between GDP per capita and EF. This was not the case, however. We did observe a correlation between individualism scores and EF for countries having GDP per capita greater than 40,000 US dollars (Fig. 8c,  $r = .730$ , CI = [.146, .932]). Among these countries, the correlation between GDP per capita and EF was lacking ( $r = -.0902$ , CI = [−.391, .594]). Our supplementary analysis also revealed that among the countries having GDP per capita greater than 40,000 US dollars, countries having higher individualism scores tended to have lower percentages of those willing to pay higher prices to address climate change (Table 2).

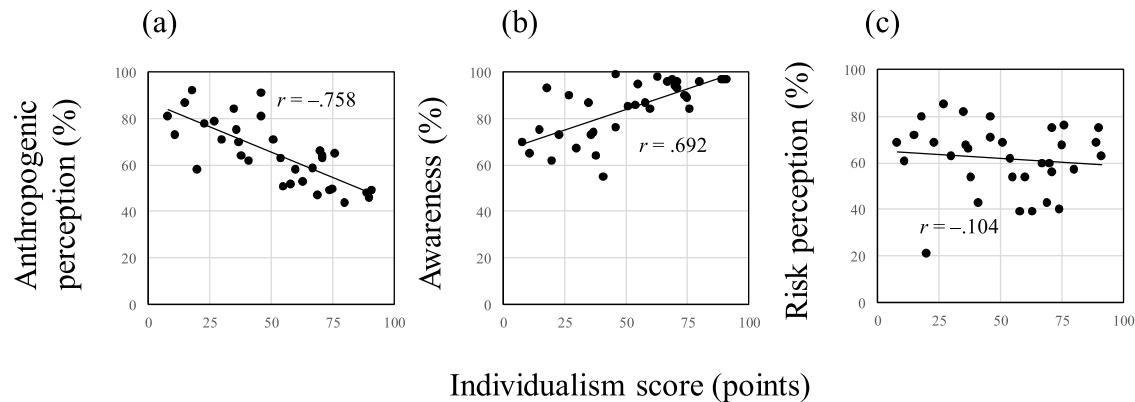
Our analysis assumed that countries having a life expectancy no less than 75.5 years were similarly developed. However, it might still be possible that some of the variables used in the analysis (e.g., individualism scores) were correlated with life expectancy, which affected our findings. We subsequently confirmed this was not the case, as described in Appendix A.

## 5. Discussion

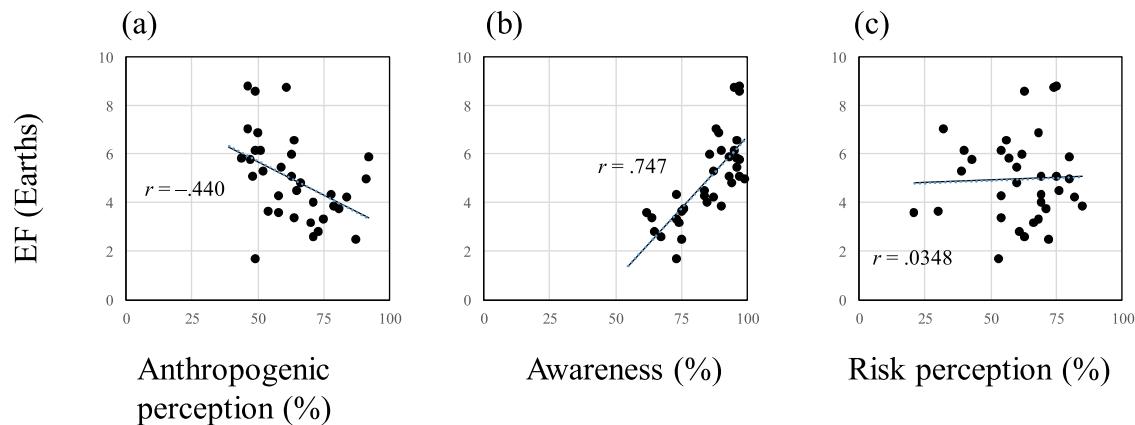
### 5.1. Does self really matter?

Correlation does not prove causation. Our exploratory argument clearly needs further examination and elaboration. Still, these empirical results suggest the possibility that culture affects actual environmental impacts, a proposition long posited by philosophers, psychologists, and other social scientists. This possibility can be grasped empirically, and this alone is important: it suggests that we should address culture as part of sustainability discussion rather than simply dismiss it out of hand on methodological grounds. These findings corroborate results of previous studies in environmental psychology cited previously (Arnocky et al., 2007; Milfont et al., 2011; Chuang et al., 2016; Davis and Stroink, 2016; Hwang and Lee, 2018). However, our study differs in that most of these previous studies used small-scale within-country (not between-country) survey data. Our study is novel in suggesting that the concept of self (i.e. self-construal) is a major factor explaining not only within-country but between-country variations in people's environmental attitudes. More importantly, our analyses revealed that cultural dimensions strongly relate not only with people's environmental attitudes but with *actual* environmental impacts. To date, this point has not been sufficiently addressed in environmental psychology which remains focused largely on perceptions and beliefs (e.g., Schultz, 2001; Schultz et al., 2005; Kahan et al., 2012; Chuang et al., 2016; Hwang and Lee, 2018).

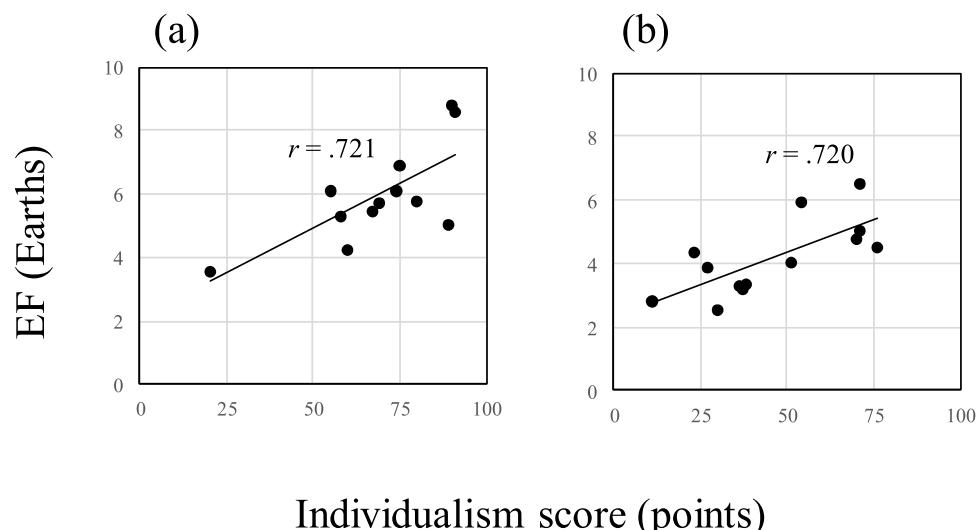
In finding that culture and self are indeed potentially a major factor for achieving environmental sustainability despite being overlooked to date, we can see that epistemological and methodological differences tend to keep scientists focused on the material (i.e., non-cultural) world, even whilst the majority of post World War II social scientists have not yet turned to discuss the physical environment (Rappleye and Komatsu, 2019). An approach, such as the one we have sketched out here, that combines social science concepts with empirical testing may help bridge the divide. Moreover, even raising the possibility of culture and self as decisive for achieving environmental sustainability helps catalyze a discussion among the entire academic community and wider public, one in which everyone, not just specialists, can participate. From this perspective, the worth of scientific studies can be judged not merely on adherence to methodological



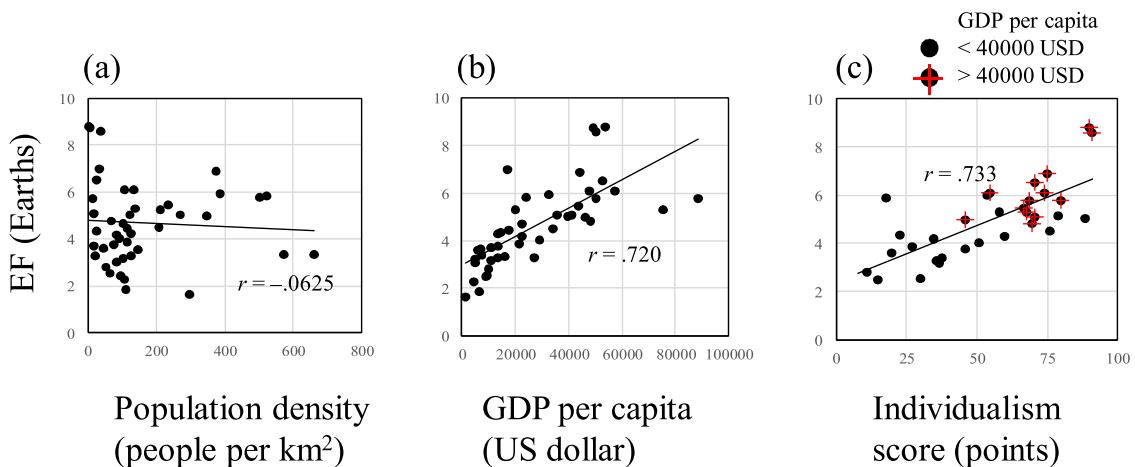
**Fig. 5.** Relationships of individualism scores with percentages of (a) anthropogenic perception, (b) awareness, and (c) risk perception.



**Fig. 6.** Relationships of percentages of (a) anthropogenic perception, (b) awareness, and (c) risk perception with Ecological Footprint of Consumption (EF).



**Fig. 7.** Relationships between individualism scores and Ecological Footprint of Consumption (EF) for countries having percentages of anthropogenic perception being (a) 40–60% and (b) 60–80%.



**Fig. 8.** Relationships of (a) the population density and (b) Gross Domestic Products (GDP) per capita with Ecological Footprint of Consumption (EF). (c) Relationship between individualism scores and EF classified according to GDP per capita.

**Table 2**

Relationship between individualism scores and willingness to pay to address climate change for the countries having GDP per capita greater than 40,000 US dollars.

| Country       | GDP per capita (US dollar) | Individualism score (points) | Percentage of respondents willing to pay |
|---------------|----------------------------|------------------------------|--|
| United States | 49,941                     | 91                           | 38                                       |
| France        | 41,268                     | 71                           | 39                                       |
| Germany       | 43,554                     | 67                           | 56                                       |
| Japan         | 46,288                     | 46                           | 61                                       |

Data for willingness to pay were derived from [Pew Research Center \(2010\)](#).

requirements and robust results, but on how much they generate substantive discussions that affect wider socio-cultural beliefs. Below we return to discuss [Kuhn \(1962\)](#) in this regard.

### 5.2. Practices to promote interdependent selfhood

The relationship between independence scores and EF, if it approximates causality, opens the possibility of rewriting patterns of self-construal as one avenue leading towards greater environmental sustainability. The next step to actualize this would be to examine what kinds of social practices prevalent in countries where interdependent selfhood is dominant.

East Asian countries (e.g., China, Japan, and South Korea), whose individualism scores are considerably lower than most Western countries (Supplementary Dataset 1), are widely recognized as having practices which promote interdependent selves ([Kasulis, 2002](#); [Tobin et al., 2009](#); [Rappleye and Komatsu, 2017](#)). Note that the scores for China, Japan, and South Korea are respectively 20, 46, and 18, while those for the Australia, United States, and United Kingdom are respectively 90, 91, and 89. Here we limit our focus to prominent differences in mass schooling practices between countries, given that schooling emerged in the modern era as the central institution for shaping cultural orientations. Moreover, today schooling affects the lives and self-construal of virtually all members of these societies.

In China, virtually all preschools have group exercise every morning ([Liu and Tobin, 2018](#)). Children need not only to master the movements independently, but to learn to synchronize their movements with others. Children first adjust their movements consciously, but eventually begin to make the adjustments unconsciously, in effect merging into an interdependent whole. In sharp contrast, group activities in American preschools and elementary schools are discouraged and choice and individualism

are valorized ([Tsuneyoshi, 2001](#); [Tobin et al., 2009](#)). American children are quite often asked by preschool teachers to choose their activities individually soon after they arrive on school grounds. In American preschools, “activities that are individually chosen are assumed to be inherently more pleasurable than that are collectively chosen or assigned” ([Tobin et al., 2009, p. 195](#)).

Another example from Japan is illustrative. In Japanese elementary schools, problems occurring in a given class are quite often dealt with through whole-class reflection sessions. This is the case even when addressing the misbehavior of a particular student ([Cave, 2007](#); [Rappleye and Komatsu, 2017](#)). The basic idea behind this approach is that the misbehavior is caused by the relationships between all members of the class. This is contrastive with the idea underlying individualized counseling, which is quite often used in Western countries (particularly Anglo-American contexts). The assumption of individualized counseling is that the misbehavior is attributable to the individual student and ‘internal’ issues. Overall, as one prominent education scholar who has spent decades observing Japanese schools confirms: “Japan’s primary schools have played a key role as places where children have learned the cooperation and empathy that are central to the interdependent self” ([Cave, 2007, p. 43](#)).

Recently, Japanese schools have been moving even further towards promoting not only between-human interdependence, but human-nature interdependence. Japan has long been using school lunch to promote interdependence among students. Specifically, elementary students serve each other meals everyday as a regular part of the school curriculum ([Tsuneyoshi, 2001](#); [Cave, 2007](#)). Now Japan is officially promoting Food Education through school lunch ([Ministry of Agriculture, Forestry and Fisheries, 2017](#); [Ministry of Education, Culture, Sports, Science and Technology, 2018](#)). The program aims to promote students’ understanding of interconnections between human and nature that are largely

rendered invisible in modernized society: inculcating lessons such as “food production is impossible without nature such as land and water” and “to eat food is to inherit lives of animals and plants” (Government of Japan, 2006). Japanese schools not only use mostly locally sourced food in preparing students’ lunch and explicitly teach students the interconnections above in a classroom setting, but also provide complementary programs to directly experience agricultural production and fisheries. Such programs, which are led by the Ministry of Education as an explicit part of education, stand in stark contrast to, as one example, American lunch programs focusing on individual choice and run by the Department of Agriculture (i.e., lunch is not seen as a component of education) (Story, 2009).

Interestingly, attempts in Western countries to introduce practices promoting interdependent selfhood in formal schooling settings are few (Sterling et al., 2018). Moreover, serious discussion about how to reimagine the scope of schooling and about, say, between-country variations in selfhood has been confined to the periphery of educational research, usually marginalized in sub-fields such as comparative philosophy and comparative education.

### 5.3. Rearticulation of natural science

Besides the implications for societies globally, our findings also imply a fundamental challenge for natural science. Many scholars assume that heightening public awareness and risk perception of environmental problems (e.g., climate change) through science education is a major key for achieving environmental sustainability (Anderson and Strecker, 2012; Houghton, 2015; Lee et al., 2015). This is reasonable. However, there may be some dangers inherent in this: promoting science education could discourage people’s disposition towards interdependent selfhood, eventually exacerbating environmental problems over the long run. The primary reason is that natural science, at least as commonly viewed by the majority of the public, assumes the independence of scientific ‘facts’ from the social relationships in which those facts arise and are embedded (Roth and Lucas, 1997; Komatsu and Rappleye, 2017a). In this view, relationships among persons are unnecessary for scientific investigation and discovery. Yet merely disseminating scientific facts without rearticulating this limited view of natural science could potentially discourage people’s disposition to the interdependent self. That is, science needs to be recognized, like education, as a set of culturally-specific practices that are in a mutually constitutive relationship with self.

An alternative view of natural science has been proposed by philosophers of science (e.g., Pickering, 1995; Ohmori, 1996; Latour, 1999). In this alternative view, a scientific fact is assumed to be constructed through interaction among scientists, scientific communities, and various other actors across society (e.g., social media, industry, and citizens). This neo-pragmatic view assumes that a scientific fact is woven in a matrix of social relationships and therefore does not discourage people’s disposition to interdependent self-construal. We thus suggest that only if scientists first successfully rearticulate natural science and then disseminate the revised view of science to wider public, will the promotion of science education effectively lead towards the path of environmental sustainability.

In addition to practical benefits, the rearticulation of natural science would make science again relevant philosophically. In the last century, philosophers of science proposed a number of paradoxes inhering in natural science (Hanson, 1958; Kuhn, 1962). For example, Hanson (1958) suggested that although science is quite often viewed as an activity to gradually approach objective Truth, its methods of observations are already influenced by scientists’ view of the world. Building on Hanson, Kuhn (1962) pointed out that a scientific truth is by nature interdependent, i.e.,

a given paradigm is that which a scientific community largely shares and guides scientists in that community to conduct their research about a particular object in a particular way. Kuhn’s concept of a ‘truth’ contradicts the classical concept of the objective Truth as that which purportedly governs distinct, independent entities. We thus believe that the rearticulation of natural science is important not only for practical purposes (i.e., achievement of environmental sustainability) but for future creativity and regeneration of natural science itself. If we are to truly avert the catastrophe trajectory, science and self both need to change. As a first step in that direction, studies that explore ways to rearticulate science need to be afforded space. Therein, a given study’s inherent potential for generation of new ideas would be afforded status equal to those focusing narrowly on meeting requirements for methodological rigor.

## 6. Conclusions

As hypothesized, we confirmed higher EF for more individualistic countries ( $r=.733$ ). We also found that data corroborated the three subhypotheses of the main hypothesis. Specifically, we observed a lower level of anthropogenic perception for more individualistic countries, higher EF for countries having lower levels of anthropogenic perception, and higher EF for more individualistic countries even among countries having a similar level of anthropogenic perception.

At least since White (1967), the importance of culture (and self) in achieving environmental sustainability has been underscored (e.g., Schumacher, 1973; Bowers, 1995, 2002; Schultz, 2001; Chuang et al., 2016). However, discussions surrounding the intersection of culture and environmental problems have remained confined to academic circles and have yet to capture the attention of policymakers and the wider public. Indeed, the summary for policymakers included in the recently released *Intergovernmental Panel on Climate Change (IPCC) report (2018)* omits discussion of both “culture” and “self”. Education, which can function as one major means to rearticulate both culture and self, is mentioned only briefly (Silova et al., 2018). Again, we surmise that one major reason for these unfortunate omissions is that very few studies have reported an empirical relationship of cultural dimensions with actual environmental impacts on Earth, as the concerns of scientists and social scientists appear to be unrelated. Our findings are a first step in bridging this divide. We hope that future studies can find ways to extend this tentative bridge in ways that connect academic discussions about culture and scientific studies of sustainability, then again with conversations among policymakers and the general public.

Although the independent self has traditionally been a major cornerstone of western civilization and further promoted as the key to achieving modernity from Descartes onward (Taylor, 1989), its era of unthinking valorization may now need to be brought to a close (Ohmori, 1996; Stengers, 2012; Haraway, 2016). To do so, we need to begin to recognize that self-construal manifests concretely in wider social arrangements and these arrangements, in turn, constitute the underlying driver of our current social trajectory. As such, rearticulating western modernity’s dominant concept of self (i.e., independent self) might be necessary to effect a departure from the present catastrophe trajectory and move – *collectively* – towards sustainability.

## Appendix A. Effect of life expectancy

Our analysis assumed that countries having a life expectancy no less than 75.5 years were similarly developed. Although some of the variables used in the analysis (e.g., individualism scores) were

correlated with life expectancy, we confirmed that such correlations did not change our findings.

Individualism scores ( $r = .474$ , CI = [.221, .688]) and EF ( $r = .497$ , CI = [.225, .712]) had correlations with the life expectancy (Figs. A1a and A1b), while anthropogenic perception did not ( $r = .0422$ , CI = [-.284, .338]; Fig. A1c). Even when excluding the dependency of independence scores and EF on life expectancy, our results did not change qualitatively. We calculated conditional individualism scores (/EF), which were defined by the difference between observed individualism scores (/EF) and those predicted using the regression line with the input of life expectancy. Even when using these conditional individualism scores and conditional EF, we observed a positive correlation between individualism scores and conditional EF ( $r = .669$ , CI = [.422, .834]; Fig. A2a), negative correlations between individualism scores and anthropogenic perception ( $r = -.504$ , CI = [-.764, -.211]; Fig. A2b) and between anthropogenic perception and EF ( $r = -.647$ , CI = [-.810, -.464]; Fig. A2c), and positive correlations between individualism scores and EF for countries having similar percentages of anthropogenic perception ( $r = .571$  and CI = [-.198, .895] for the countries having the percentage of 40–60%;  $r = .502$  and CI = [.114, .779] for the countries having the percentage of 60–80%; Figs. A2d and A2e). These results suggest that our findings were not affected by the dependency of individualism scores and EF on life expectancy.

## Appendix B. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:<https://doi.org/10.1016/j.ancene.2019.100198>.

## References

Adams, G., Markus, H., 2004. Toward a conception of culture suitable for a social psychology of culture. In: Schaller, M., Crandall, C.S. (Eds.), *The Psychological Foundations of Culture*. Erlbaum, Hillsdale, NJ, pp. 335–360.

Adger, W.N., Barnett, J., Brown, K., Marshall, N., O'Brien, K., 2013. Cultural dimensions of climate change impacts and adaptation. *Nature Climate Change* 3, 112–117. doi:<http://dx.doi.org/10.1038/nclimate1666>.

Anderson, A., Strecker, M., 2012. Sustainable development: a case for education. *Environ. Sci. Policy Sust. Develop.* 54, 3–16. doi:<http://dx.doi.org/10.1080/00139157.2012.730010>.

Arnocky, S., Stoink, M., DeCicco, T., 2007. Self-construal predicts environmental concern, cooperation, and conservation. *J. Environ. Psychol.* 27, 255–264. doi:<http://dx.doi.org/10.1016/j.jenvp.2007.06.005>.

Berkson, J., 1938. Some difficulties of interpretation of interpolation encountered in the application of the chi-square test. *J. Ame. Stat. Assoc.* 33, 526–536.

Bowers, C.A., 1995. Educating for an Ecologically Sustainable Culture: Rethinking Moral Education, Creativity, Intelligence, and Other Modern Orthodoxies. State University of New York, New York.

Bowers, C.A., 2002. Towards an eco-justice pedagogy. *Environ. Edu. Res.* 8, 21–34. doi:<http://dx.doi.org/10.1080/13504620120109628>.

Bradshaw, C.J.A., Giam, X., Sodhi, N.S., 2010. Evaluating the relative environmental impact of countries. *Plos One* 5, e10440 doi:<http://dx.doi.org/10.1371/journal.pone.0010440>.

Brechin, S.R., Bhandari, M., 2011. Perceptions of climate change worldwide. *WIREs Clim. Change* 2011 (2), 871–885. doi:<http://dx.doi.org/10.1002/wcc.146>.

Cave, P., 2007. Primary School in Japan: Self, Individuality and Learning in Elementary Education. Routledge, London.

Chuang, Y., Xie, X., Liu, C., 2016. Interdependent orientations increase pro-environmental preferences when facing self-interest conflicts: the mediating role of self-control. *J. Environ. Psychol.* 46, 96–105. doi:<http://dx.doi.org/10.1016/j.jenvp.2016.04.001>.

Crimmins, E.M., Saito, Y., 2001. Trends in healthy life expectancy in the United States, 1970–1990: gender, racial, and educational differences. *Soc. Sci. Med.* 52, 1629–1641. doi:[http://dx.doi.org/10.1016/S0277-9536\(00\)00273-2](http://dx.doi.org/10.1016/S0277-9536(00)00273-2).

Davis, A.C., Stoink, M.L., 2016. Within-culture differences in self-construal, environmental concern, and proenvironmental behavior. *Ecopsychol.* 8, 64–73. doi:<http://dx.doi.org/10.1089/eco.2015.0061>.

Diadonis, P., Efron, B., 1983. Computer-intensive methods in statistics. *Sci. Am.* 248, 116–131.

Dunlap, R.E., Van Liere, K.D., Mertig, A.G., Jones, R.E., 2000. New trends in measuring environmental attitudes: measuring endorsement of the new ecological paradigm: a revised NEP scale. *J. Soc. Issues* 56, 425–442. doi:<http://dx.doi.org/10.1111/0022-4537.00176>.

Falkner, R., 2016. The Paris agreement and the new logic of international climate politics. *Int. Affairs* 92, 1107–1125. doi:<http://dx.doi.org/10.1111/1468-2346.12708>.

Frantz, C., Mayer, F.S., Norton, C., Rock, M., 2005. There is no “I” in nature: the influence of self-awareness on connectedness to nature. *J. Environ. Psychol.* 25, 427–436. doi:<http://dx.doi.org/10.1016/j.jenvp.2005.10.002>.

Gifford, R., 2011. The dragons of inaction: psychological barriers that limit climate change mitigation and adaptation. *Ame. Psychol.* 66, 290–302. doi:<http://dx.doi.org/10.1037/a0023566>.

Gifford, R., 2014. Environmental psychology matters. *Annu. Rev. Psychol.* 65, 541–579. doi:<http://dx.doi.org/10.1146/annurev-psych-010213-115048>.

Global Footprint Network, 2017. Public Data Package 2017. . (Accessed 24 October 2018) <http://www.footprintnetwork.org/licenses/public-data-package-free-edition-copy>.

Government of Japan, 2006. Master Plan for Promoting Food Education. . (Accessed 24 October 2018) <http://warp.da.ndl.go.jp/info:ndljp/pid/9929094/www8.cao.go.jp/syokuiku/suisin/kihonkeikaku.html>.

Hanson, N.R., 1958. *Patterns of Discovery: An Inquiry into the Conceptual Foundations of Science*. Cambridge University Press, Cambridge.

Haraway, D., 2016. *Staying With the Trouble: Making Kin in the Chthulucene*. Duke University Press, Durham, N.C.

Heine, S.J., Ruby, M.B., 2010. Cultural psychology. *WIREs Cogn. Sci.* 1, 254–266. doi:<http://dx.doi.org/10.1002/wcs.7>.

Hofstede, G., Hofstede, G.J., Minkov, M., 2010. *Cultures and Organizations: Software of the Mind*, 3rd edition McGraw Hill, New York.

Houghton, J., 2015. *Global Warming: The Complete Briefing*, fifth edition Cambridge University Press, Cambridge.

Hwang, K., Lee, J., 2018. Antecedents and consequences of ecotourism behavior: independent and interdependent self-construals, ecological belief, willingness to pay for ecotourism services and satisfaction with life. *Sustainability* 10, 789–807. doi:<http://dx.doi.org/10.3390/su10030789>.

IPCC, 2018. Special Report on Climate Change (Summary for Policymakers). . (Accessed 24 October 2018) [http://report.ipcc.ch/sr15/pdf/sr15\\_spm\\_final.pdf](http://report.ipcc.ch/sr15/pdf/sr15_spm_final.pdf).

Jackson, T., 2009. *Prosperity Without Growth: Economics for a Finite Planet*. Earthscan, New York.

Kahan, D.M., Peters, E., Wittlin, M., Slovic, P., Ouellette, L.L., Braman, D., Mandel, G., 2012. The polarizing impact of science literacy and numeracy on perceived climate change risks. *Nature Clim. Chan.* 2, 732–735. doi:<http://dx.doi.org/10.1038/NCLIMATE1547>.

Kasulis, T.P., 2002. *Intimacy or Integrity: Philosophy and Cultural Difference*. University of Hawai'i Press, Honolulu.

Klein, N., 2014. *This Changes Everything: Capitalism vs. the Climate*. Simon & Schuster, New York.

Komatsu, H., Rappleye, J., 2017a. Incongruity between scientific knowledge and ordinary perceptions of nature: an ontological perspective for forest hydrology in Japan. *J. For. Res.* 22, 75–82. doi:<http://dx.doi.org/10.1080/13416979.2017.1283977>.

Komatsu, H., Rappleye, J., 2017b. A new global policy regime founded on invalid statistics? Hanushek, Woessmann, PISA, and economic growth. *Comp. Educ.* 53, 166–191. doi:<http://dx.doi.org/10.1080/03050068.2017.1300008>.

Kuhn, T., 1962. *The Structure of Scientific Revolutions*. University of Chicago Press, Chicago.

Latour, B., 1999. *Pandora's Hope: Essays on the Reality of Science*. Harvard University Press, Cambridge.

Lee, J.A., Holden, S.J., 1999. Understanding the determinants of environmentally conscious behavior. *Psychol. Market.* 16, 373–392. doi:[http://dx.doi.org/10.1002/\(SICI\)1520-6793\(199908\)16:5<373::AID-MAR1>3.0.CO;2-S](http://dx.doi.org/10.1002/(SICI)1520-6793(199908)16:5<373::AID-MAR1>3.0.CO;2-S).

Lee, T.M., Ezra, E.M., Markowitz, Howe P.D., Ko, C.Y., Leiserowitz, A.A., 2015. Predictors of public climate change awareness and risk perception around the world. *Nat. Climate Change* 5, 1014–1023. doi:<http://dx.doi.org/10.1038/NCLIMATE2728>.

Linderoth, H., 2002. Forecast errors in IEA-countries' energy consumption. *Energ. Pol.* 30, 53–61. doi:[http://dx.doi.org/10.1016/S0301-4215\(01\)00059-3](http://dx.doi.org/10.1016/S0301-4215(01)00059-3).

Liu, C., Tobin, J., 2018. Group exercise in Chinese preschools in an era of child-centered pedagogy. *Comp. Educ.* 62, 5–30. doi:<http://dx.doi.org/10.1086/695486>.

Lubell, M., 2002. Environmental activism as collective action. *Environ. Behav.* 34, 431–454. doi:<http://dx.doi.org/10.1177/00116502034004002>.

Markus, H.R., Kitayama, S., 1991. Culture and the self: implications for cognition, emotion, and motivation. *Psychol. Rev.* 98, 224–253. doi:<http://dx.doi.org/10.1037/0033-295X.98.2.224>.

Markus, H.R., Kitayama, S., 2010. Cultures and selves: a cycle of mutual constitution. *Perspect. Psychol.* 5, 420–430. doi:<http://dx.doi.org/10.1177/1745691610375557>.

Martinsson, P., Myrseth, K.O.R., Wollbrant, C., 2012. Reconciling pro-social vs. selfish behavior: on the role of self-control. *Judg. Decis. Mak.* 7, 304.

Meadows, D.H., Meadows, D.L., Randers, J., Behrens III, W.W., 1972. *The Limits to Growth*. Universe Book, New York.

Meadows, D., Randers, J., Meadows, D., 2004. *The Limits to Growth: the 30-Year Update*. Chelsea Green Publishing, White River Junction.

Mehrara, M., 2007. Energy consumption and economic growth: the case of oil exporting countries. *Energy Pol.* 35, 2939–2945. doi:<http://dx.doi.org/10.1016/j.enpol.2006.10.018>.

Milfont, T.L., Davis, L., Konrad, C., 2011. Views of the Self and Environmental Attitudes: An Experimental Examination (A Paper Presented at the 9th Biennial Conference on Environmental Psychology, Eindhoven, The Netherlands). . (Accessed 6 January 2019) <http://proceedings.envpsych2011.eu/files/doc/227.pdf>.

Ministry of Agriculture, Forestry and Fisheries, 2017. Basic Act on Food Education. . (Accessed 24 October 2018) [http://www.maff.go.jp/j/syokuiku/pdf\\_kihonho\\_28.pdf](http://www.maff.go.jp/j/syokuiku/pdf_kihonho_28.pdf).

Ministry of Education, Culture, Sports, Science and Technology, 2018. Promotion of Food Education and Improvement of School Lunch in Schools. . (Accessed 24 October 2018) [http://www.mext.go.jp/a\\_menu/sports/syokuiku/index.htm](http://www.mext.go.jp/a_menu/sports/syokuiku/index.htm).

Morris, M.W., Peng, K., 1994. Culture and cause: American and Chinese attributions for social and physical events. *J. Person. Social Psychol.* 67, 949–971. doi:<http://dx.doi.org/10.1037/0022-3514.67.6.949>.

Nisbett, R.E., 2003. *The Geography of Thought: How Asians and Westerners Think Differently... and Why?* Free Press, New York.

Nisbett, R.E., Masuda, T., 2003. Culture and point of view. *Proc. Nat. Acad. Sci.* 100, 1163–1170. doi:<http://dx.doi.org/10.1073/pnas.1934527100>.

Nuzzo, R., 2014. Scientific methods: statistical errors. *Nature* 506, 150–152. doi:<http://dx.doi.org/10.1038/506150a>.

Ohmori, S., 1996. *Tokiha nagarezu [Time Does Not Flow]*. Seidosha, Tokyo (in Japanese).

Olshansky, S.J., Antonucci, T., Berkman, L., Binstock, R.H., Boersch-Supan, A., Cacioppo, J.T., Carnes, B.A., Carstensen, L.L., Fried, L.P., Goldman, D.P., Jackson, J., Kohli, M., Rother, J., Zheng, Y., Rowe, J., 2012. Differences in life expectancy due to race and educational differences are widening, and many may not catch up. *Health Affairs* 31, 1803–1813. doi:<http://dx.doi.org/10.1377/hlthaff.2011.0746>.

Onel, N., Mukherjee, A., 2014. The effects of national culture and human development on environmental health. *Environ. Dev. Sustain.* 16, 79–101.

Orr, D., 1998. *Earth in Mind: On Education, Environment, and the Human Prospect*. Island Press, Washington.

Park, H., Russell, C., Lee, J., 2007. National culture and environmental sustainability: a cross-national analysis. *J. Econ. Finan.* 31, 104–121. doi:<http://dx.doi.org/10.1007/BF02751516>.

Passarino, G., De Rango, F., Montesanto, A., 2016. Human longevity: genetics or lifestyle? It takes two to tango. *Immun. Age* 13, 12. doi:<http://dx.doi.org/10.1186/s12979-016-0066-z>.

Pelham, B.R., 2009. Awareness, Opinions About Global Warming Vary WorldwideGallup. . (Accessed 24 October 2018) <http://news.gallup.com/poll/11772/Awareness-Opinions-Global-Warming-Vary-Worldwide.aspx>.

Peng, Y.S., Lin, S.S., 2009. National culture, economic development, population growth and environmental performance: the mediating role of education. *J. Bus. Ethics* 90, 203–219. doi:<http://dx.doi.org/10.1007/s10551-009-0036-x>.

Pew Research Center, 2010. Global Attitudes Project (June 17, 2010). Pew Research Center, Washington.

Pew Research Center, 2015. Global Concern About Climate Change, Broad Support for Limiting Emissions. Pew Research Center, Washington.

Pickering, A., 1995. *The Mangle of Practice: Time, Agency, and Science*. The University of Chicago Press, Chicago.

Pugliese, A., Ray, J., 2009. Top-Emitting Countries Differ on Climate Change Threat. . (Accessed 24 October 2018) <http://news.gallup.com/poll/124595/Top-Emitting-Countries-Differ-Climate-Change-Threat.aspx#2>.

Randers, J., 2012. 2052: Global Forecast for the Next Forty Years. Chelsea Green Publishing, White River Junction, Vermont.

Rappleye, J., Komatsu, H., 2017. How to make Lesson Study work in America and worldwide: a Japanese perspective on the onto-cultural basis of (teacher) education. *Res. Comp. Int. Educ.* 12, 398–430. doi:<http://dx.doi.org/10.1177/1745499917740656>.

Rappleye, J., Komatsu, H., 2019. Towards (comparative) educational research for a finite future. *Comp. Educ.* in review.

Roth, W.M., Lucas, K.B., 1997. From "Truth" to "invented reality": a discourse analysis of high school physics students' talk about scientific knowledge. *J. Res. Sci. Teach.* 34, 145–179. doi:[http://dx.doi.org/10.1002/\(SICI\)1098-2736\(199702\)34:2<145::AID-TEA4>3.0.CO;2-T](http://dx.doi.org/10.1002/(SICI)1098-2736(199702)34:2<145::AID-TEA4>3.0.CO;2-T).

Schultz, P.W., 2001. The structure of environmental concern: concern for self, other people, and the biosphere. *J. Environ. Psychol.* 21, 327–339. doi:<http://dx.doi.org/10.1006/jevp.2001.0227>.

Schultz, P.W., Gouveia, V.V., Cameron, L.D., Tankha, G., Schmuck, P., Franek, M., 2005. Values and their relationship to environmental concern and conservation behavior. *J. Cross-Cult. Psychol.* 36, 457–475. doi:<http://dx.doi.org/10.1177/0022022105275962>.

Schumacher, E.F., 1973. *Small Is Beautiful: A Study of Economics as If People Mattered*. Blond & Briggs, London.

Seeley, E.A., Gardner, W.L., 2003. The "Selfless" and self-regulation: the role of chronic other-orientation in averting self-regulatory depletion. *Self Ident.* 2, 103e117.

Siche, J.R., Agostinho, F., Ortega, E., Romeiro, A., 2008. Sustainability of nations by indices: comparative study between environmental sustainability index, ecological footprint and the energy performance indices. *Ecol. Econ.* 66, 628–637. doi:<http://dx.doi.org/10.1016/j.ecolecon.2007.10.023>.

Silova, I., Komatsu, H., Rappleye, J., 2018. Facing the Climate Change Catastrophe: Education as Solution or Cause? NORRAG. October 12 <https://www.norrag.org/facing-the-climate-change-catastrophe-education-as-solution-or-cause-by-iveta-silova-hikaru-komatsu-and-jeremy-rappleye/> (Accessed 24 October 2018).

Stengers, I., 2012. Reclaiming Animism vol. 36. e-Flux. . (Accessed 24 October 2018) <http://www.eflux.com/journal/reclaiminganimism/>.

Sterling, S., Dawson, J., Warwick, P., 2018. Transforming sustainability education at the creative edge of the mainstream: a case study of Schumacher College. *J. Transform. Educ.* 16, 323–343. doi:<http://dx.doi.org/10.1177/1541344618784375>.

Story, M., 2009. The third school nutrition dietary assessment study: findings and policy implications for improving the health of US children. *J. Ame. Diet. Assoc. (Supplement)*, S7–S13. doi:<http://dx.doi.org/10.1016/j.jada.2008.11.005>.

Stroink, M., DeCicco, T., 2011. Culture, religion, and the underlying value dimensions of the metapersonal self-construal. *Men. Health Relig. Cul.* 14, 917–934. doi:<http://dx.doi.org/10.1080/13674676.2010.536979>.

Taylor, C., 1989. *Sources of Self*. Harvard University Press, Cambridge, Mass.

Thompson, B., 2002. What future quantitative social science research could look like: confidence intervals for effect sizes. *Educ. Res.* 31, 25–32. doi:<http://dx.doi.org/10.3102/0013189X031003025>.

Tobin, J., Hsueh, Y., Karasawa, M., 2009. *Preschool in Three Cultures Revisited: China, Japan, and the United States*. University of Chicago Press, Chicago.

Triandis, H.C., 1995. *Individualism and Collectivism*. Westview, Boulder, CO.

Tsuneyoshi, R., 2001. *The Japanese Model of Schooling: Comparison With the United States*. Routledge, New York.

Turner, G., 2008. A comparison of *The Limits to Growth* with thirty years of reality. *Glob. Environ. Change* 18, 397–411. doi:<http://dx.doi.org/10.1016/j.gloenvcha.2008.05.001>.

Turner, G., 2012. On the cusp of global collapse? Updated comparison of the limits of growth with historical data. *Gaia* 21, 116–124. doi:<http://dx.doi.org/10.14512/gaia.21.2.10>.

UNDP, 2016. *The Human Development Index 2016*. . (Accessed 24 October 2018) [http://www.nationsonline.org/oneworld/human\\_development.htm](http://www.nationsonline.org/oneworld/human_development.htm).

Voronov, M., Singer, J., 2002. The myth of individualism-collectivism: a critical review. *J. Social Psychol.* 142, 461–480. doi:<http://dx.doi.org/10.1080/00224540209603912>.

Wang, C.L., 2016. Towards self-realisation; exploring the ecological self for education. *Edu. Phil. Theor.* 48, 1256–1265. doi:<http://dx.doi.org/10.1080/00131857.2016.1158090>.

Weber, E.U., 2010. What shapes perceptions of climate change? *WIREs Clim. Change* 1, 332–342. doi:<http://dx.doi.org/10.1002/wcc.41>.

Weber, C.L., Peters, G.P., Guan, D., Hubacek, K., 2008. The contribution of Chinese exports to climate change. *Energy Pol.* 36, 3572–3577. doi:<http://dx.doi.org/10.1016/j.enpol.2008.06.009>.

White, L., 1967. The historical roots of our ecologic crisis. *Science* 155, 1203–1207. doi:<http://dx.doi.org/10.1126/science.155.3767.1203>.

Wilson, J., Tyedmers, P., Pelot, R., 2007. Contrasting and comparing sustainable development indicator metrics. *Ecol. Ind.* 7, 299–314. doi:<http://dx.doi.org/10.1016/j.ecolind.2006.02.009>.

World Bank, 2009. *Public Attitudes Toward Climate Change: Findings from Multi-Country Poll*. The World Bank, Washington.

World Bank, 2017. *World Bank Open Data*. . (Accessed 24 October 2018) <https://data.worldbank.org/>.

York, R., Rosa, E.A., Dietz, T., 2004. The ecological footprint intensity of national economies. *J. Ind. Ecol.* 8, 139–154. doi:<http://dx.doi.org/10.1162/1088198043630487>.